



ARSET

Applied Remote Sensing Training

<http://arset.gsfc.nasa.gov>

 @NASAARSET

Water Quality Monitoring Using NASA Remote Sensing Observations

Short Course, National Monitoring Conference
May 5, 2016 (8:30 AM – 12 PM)

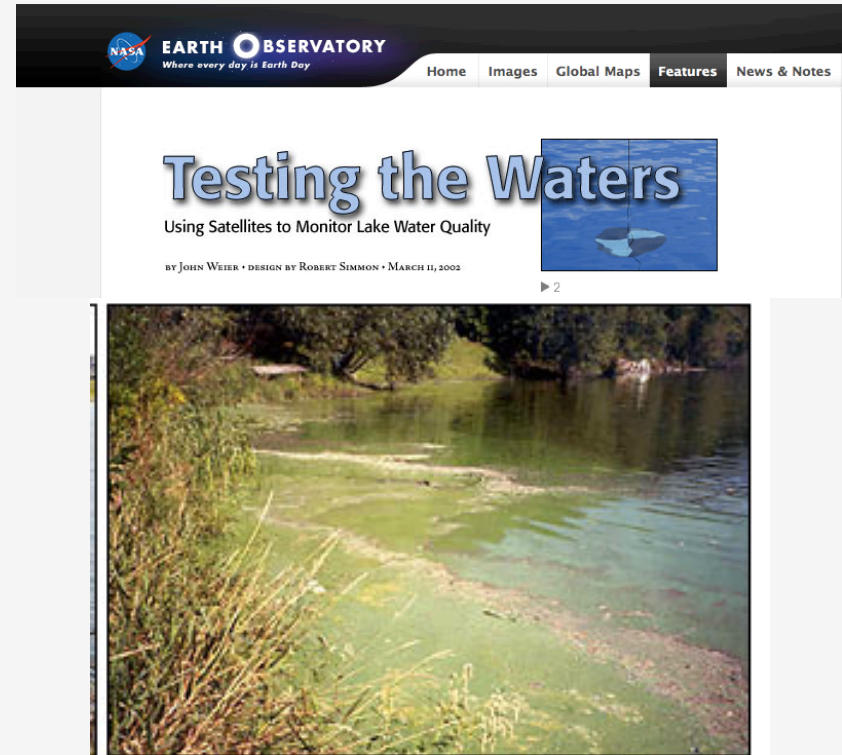
Instructors:

Amita Mehta (NASA-UMBC-JCET)

Cédric G. Fichot (NASA-JPL)

Objectives

- Provide an overview of NASA remote sensing observations relevant for monitoring water quality (WQ) in coastal oceans, estuaries, and lakes
- Provide training in using web-tools to access the remote sensing imagery and WQ parameters (e.g. Chlorophyll Concentration)
- Provide hands-on experience in access, interpretation, and applications of the remote sensing data for WQ monitoring with the aid of specific case studies




Expected Outcome

- Gain knowledge and ability to access, analyze, and apply satellite remote sensing data for water quality monitoring and management needs
- Learn about advantages and limitations of using remote sensing observations for WQ applications
- There will be an opportunity to provide feedback about the training material and future areas of interest
- More advanced, regionally focused training can be requested that includes downloading and installing/running software to manipulate satellite data to use in WQ applications

Agenda

- Introduction to ARSET (8:30 – 8:40 AM)
- Presentation (8:40 – 9:15 AM)
 - Overview of NASA Remote Sensing Data and Data Access Tools Relevant for Water Quality Monitoring
- Hands-on Exercise of using NASA Web-tools (9:15 – 10:00 AM)
 - Learn to use OceanColor Web and Giovanni: Selection, Visualization, and Downloading water quality (WQ) data
 - Analysis of near-real time and past Chlorophyll-a Concentration in the Great Lakes and Gulf of Mexico
- Break (10:00 – 10:30 AM)
- Demonstration and Follow-along Exercise (10:30 AM – 11:45 AM)
 - Demonstration of GloVIS – learn to access and interpret LANDSAT Imagery
- Course Summary and Question/Answer (11:45 AM – 12 PM)



ARSET

Applied remote Sensing Training program

<http://arset.gsfc.nasa.gov>

ARSET Training Areas

An Applied Sciences Capacity Building Program



Disasters



Ecological
Forecasting



Health & Air Quality



Water Resources



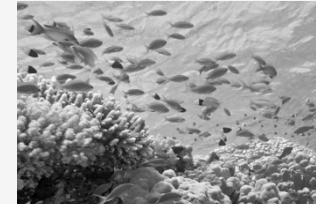
Agriculture



Climate



Energy



Oceans



Meteorology

ARSET Team

Water Resources Team:

- Brock Blevins (UMBC/JCET)
- Amita Mehta (UMBC/JCET)
- Kyle Peterson (UMBC/JCET)
- Cédric Fichot (NASA/JPL)
- Erika Podest (NASA/JPL)
- Tim Stough (NASA/JPL)

Program Manager:

- Ana Prados (UMBC/JCET)

ARSET

<http://arset.gsfc.nasa.gov>

Training activities for environmental professionals to increase usage of NASA observational and modeling data for decision-making support.

Online Webinars

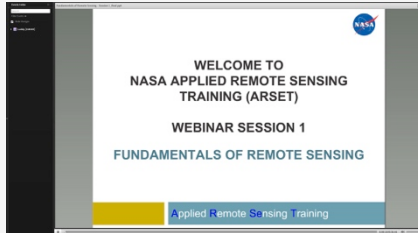
- 1 hour a week, 4-6 weeks
- Live & recorded
- Include demos on data access

In-person Workshops

- Held in a computer lab for 2 - 4 days
- Focus on data access
- Locally relevant case studies

Train the Trainers

- Courses & training manuals for those interested in doing their own remote sensing trainings



ARSET Trainings

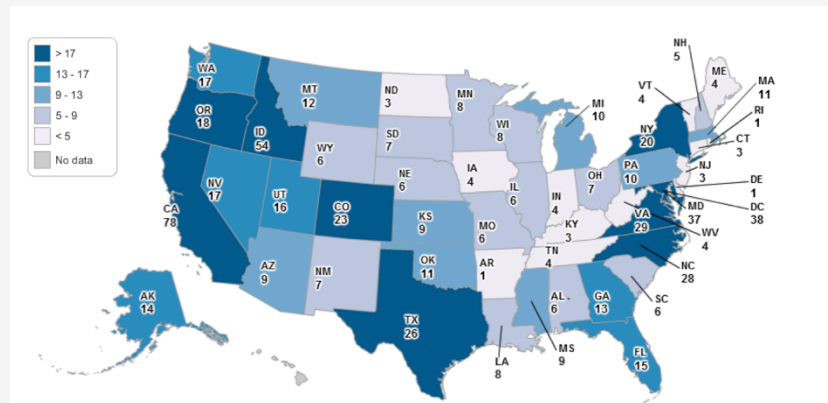
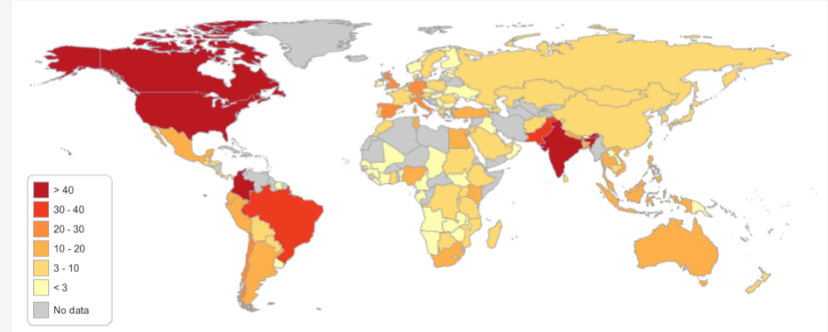
Accomplishments (2008-present)

- 66 Trainings Completed
- 4,000+ participants worldwide from:
 - 1,400+ organizations
 - 130+ countries

"I think the largest benefit to me will be just learning the basics and gaining an understanding of what products and applications are available and how I potentially use these products to help with my responsibilities as a land manager."

-Participant of a 2015 Wildfire Workshop

Participating Organizations by Country & U.S. States (2008-2015)



ARSET Trainings

Gradual Learning Approach

Basic Trainings

Webinars & Workshops
Assumes no prior RS knowledge

Example: 2014 Webinar
Water Quality Monitoring Using
Remote Sensing Measurements
<http://go.nasa.gov/1STVxa9>

Advanced Trainings

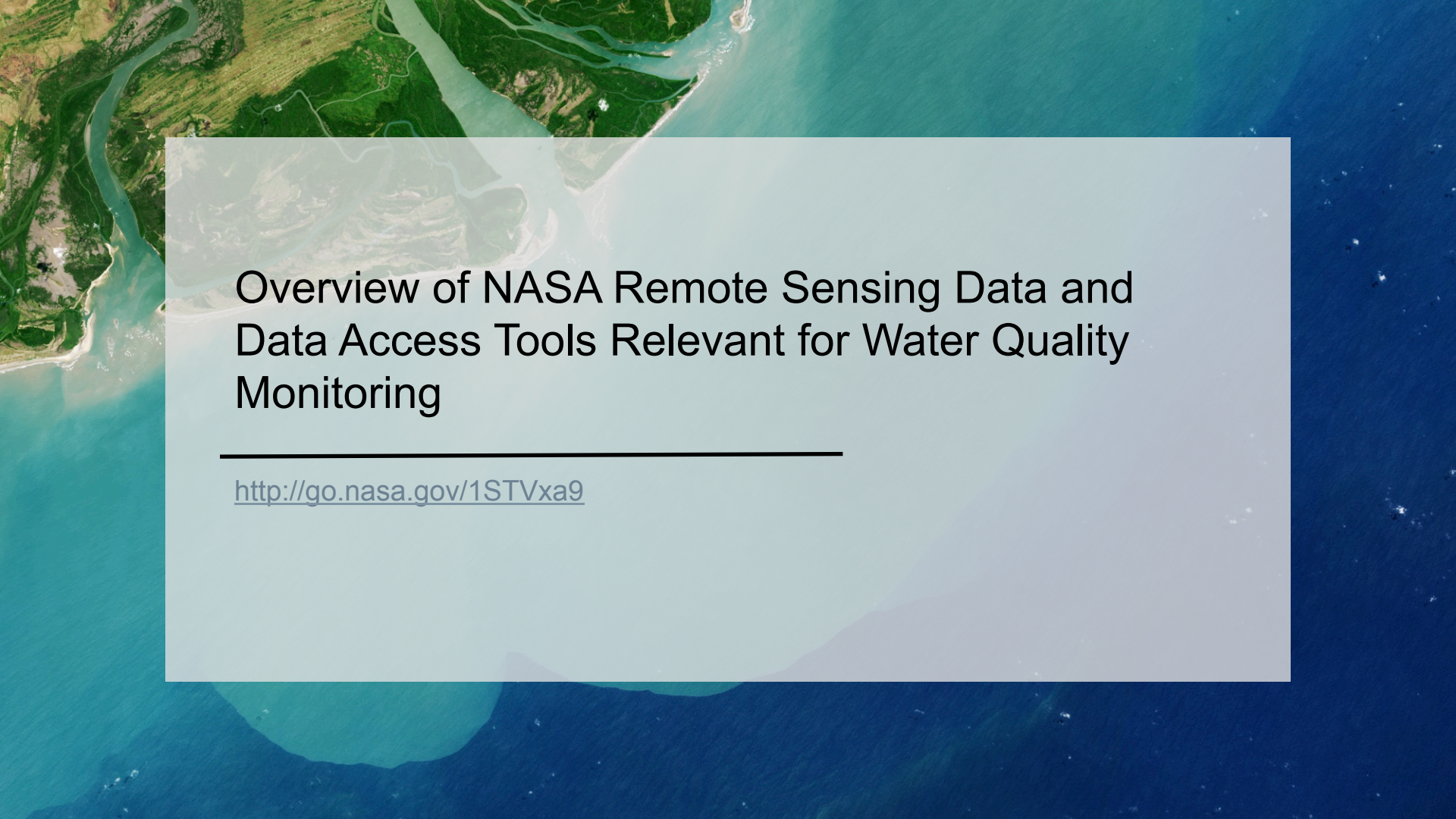
Webinars & Workshops
Requires basic training
Focuses on specific application
problems and data

Example:
Algal bloom monitoring in the
Great Lakes

ARSET Listserv

For information on upcoming courses and program updates, please sign up to the listserv

<https://lists.nasa.gov/mailman/listinfo/arset>

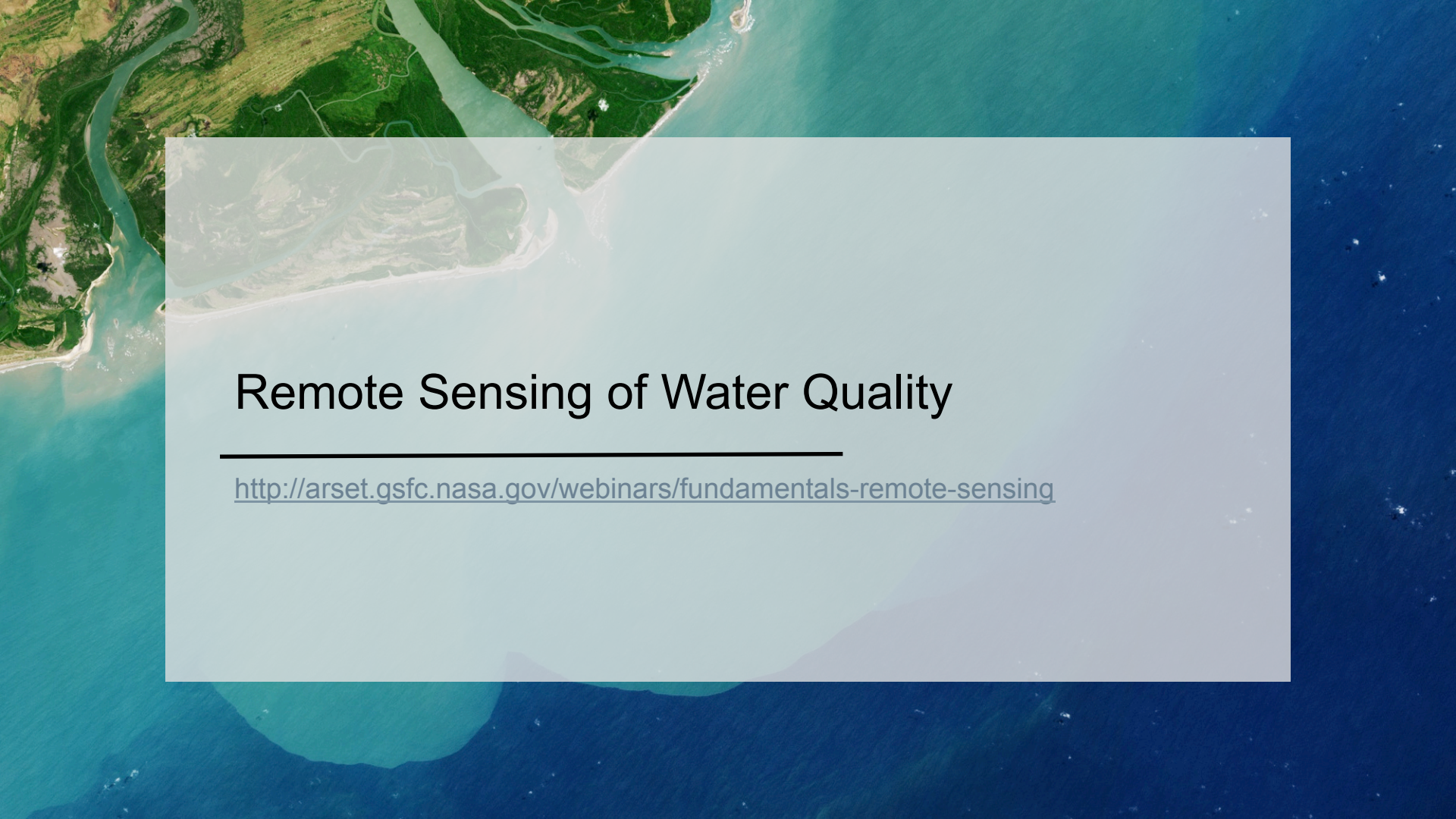
A satellite image of a coastal region, likely the Amazon River delta, showing a complex network of waterways and green land. The image is used as a background for the slide.

Overview of NASA Remote Sensing Data and Data Access Tools Relevant for Water Quality Monitoring

<http://go.nasa.gov/1STVxa9>

Outline

- Remote Sensing of Water Quality
- Satellites and Sensors Useful for WQ Remote Sensing
- WQ Data and Demonstration of Web-tools to Visualize and Access the Data
- Strengths and Limitations of the Remote Sensing Data for WQ Monitoring
- Examples of NASA Remote Sensing Applications WQ Monitoring

A satellite image of a coastal region, likely the Amazon River delta, showing a complex network of waterways and surrounding land. The water is a mix of light blue and green, indicating varying depths and possibly sediment or vegetation. The land is a mix of green and brown, suggesting a mix of forest and cleared areas. A semi-transparent white box is overlaid on the right side of the image, containing the title and a URL.

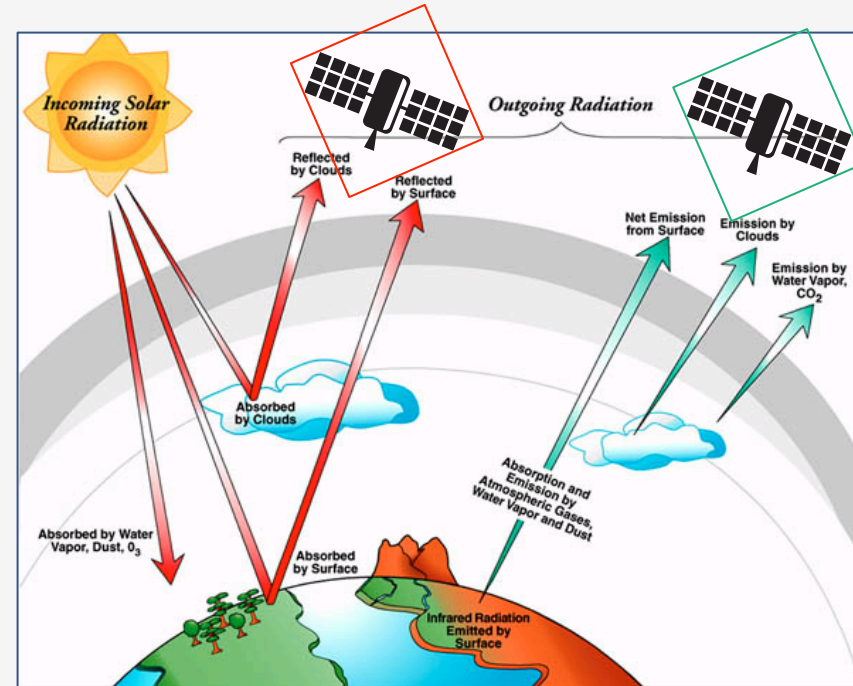
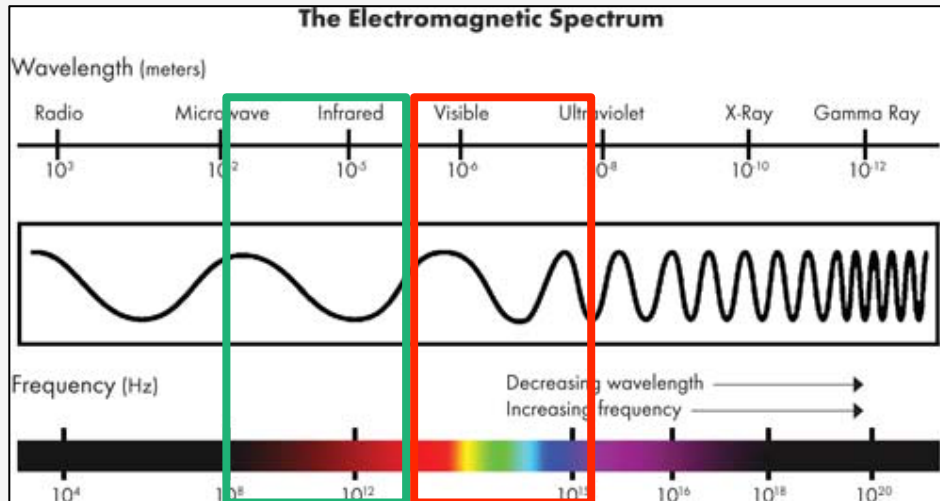
Remote Sensing of Water Quality

<http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>

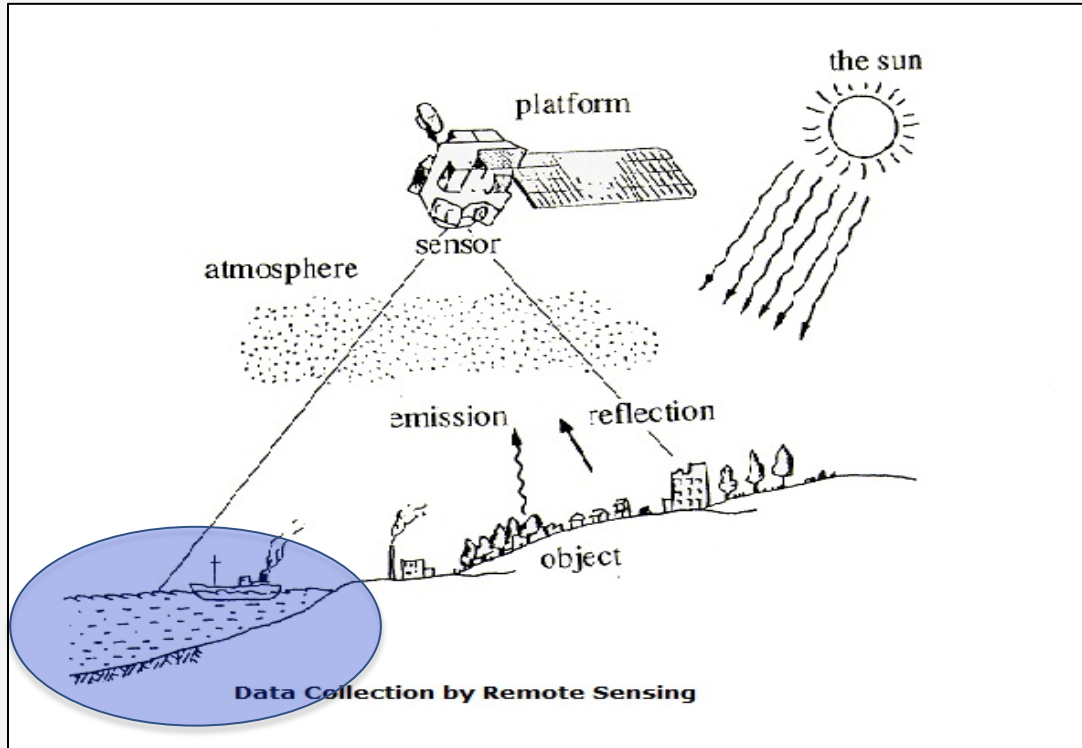
Satellite Remote Sensing

Satellites carry instruments/sensors to measure:

- **reflected solar radiation**
- **emitted infrared and microwave radiation**



Satellite measurements carry information about:



Atmosphere

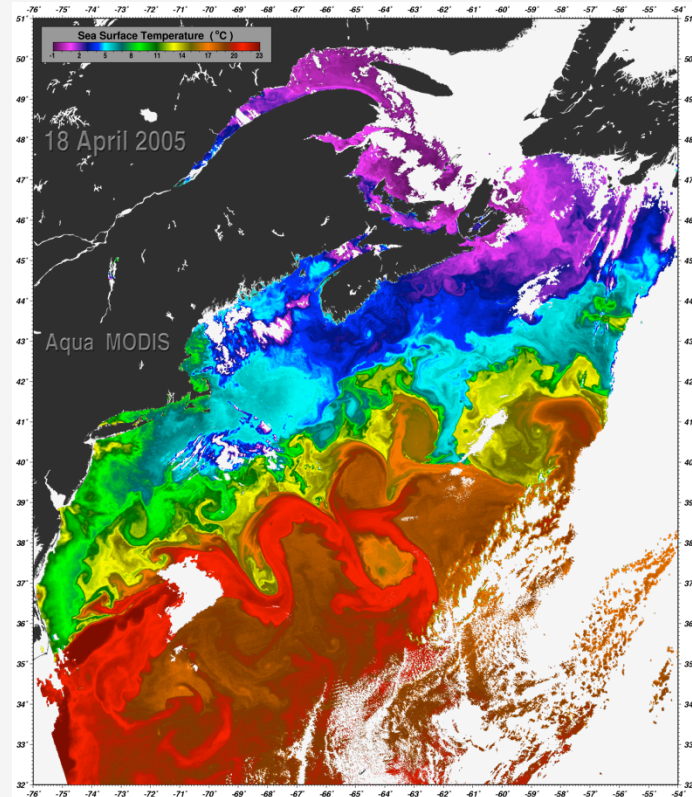
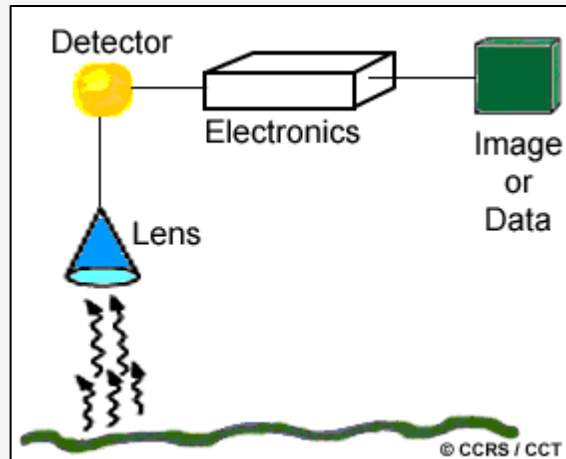
- Clouds
- Aerosols
- Gases

Earth's Surface

- Snow/Ice
- Land
 - Land use
 - Vegetation
- **Water**

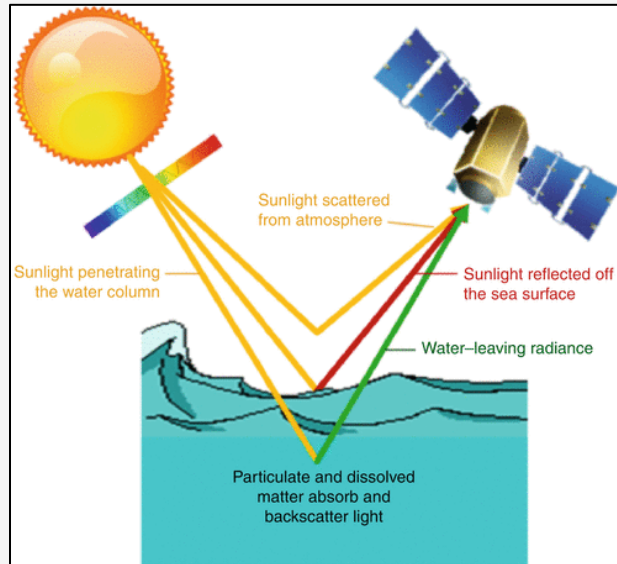
Remote Sensing of Water Bodies

Emitted thermal infrared radiation can be measured by satellite sensors, and used to derive the temperature of surface water bodies.



Remote Sensing of Water Bodies

Reflected solar radiation (~ color of the water) is measured by satellite sensors, and used to derive the properties of optically-active water constituents:



- Suspended sediments
- Algae
- Dissolved Organic Matter
- Detrital Organic Matter
- Submerged/Floating vegetation
- Oil



- Contaminants
- Pathogens

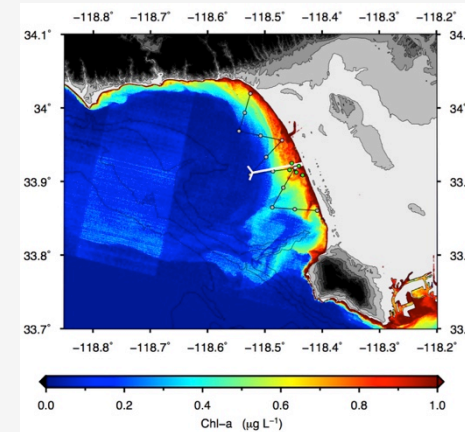
Remote Sensing of Water Bodies

Techniques

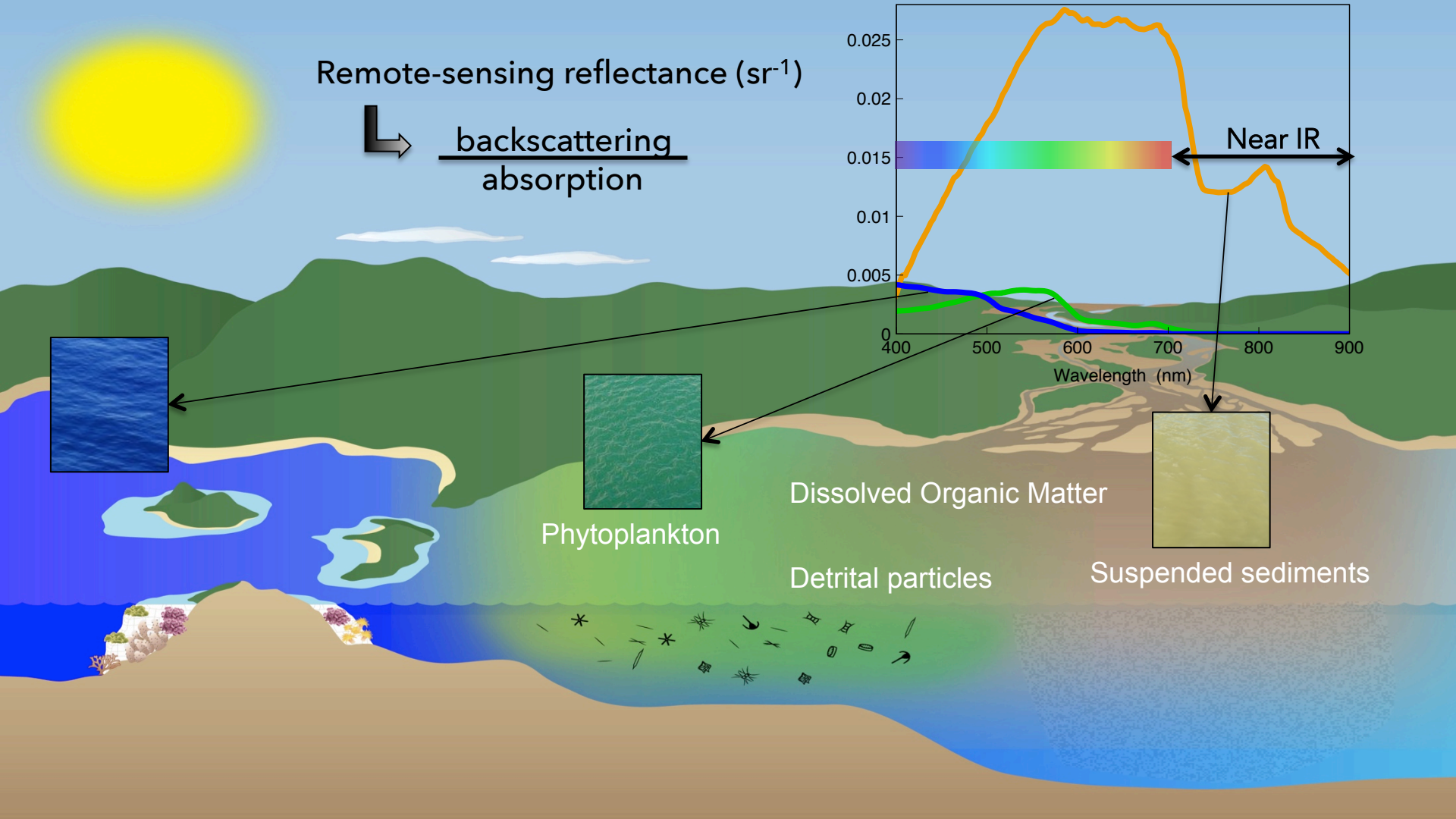
Simple image interpretation to derive QUALITATIVE information about water quality



Use of various types of algorithms to derive QUANTITATIVE information about water quality



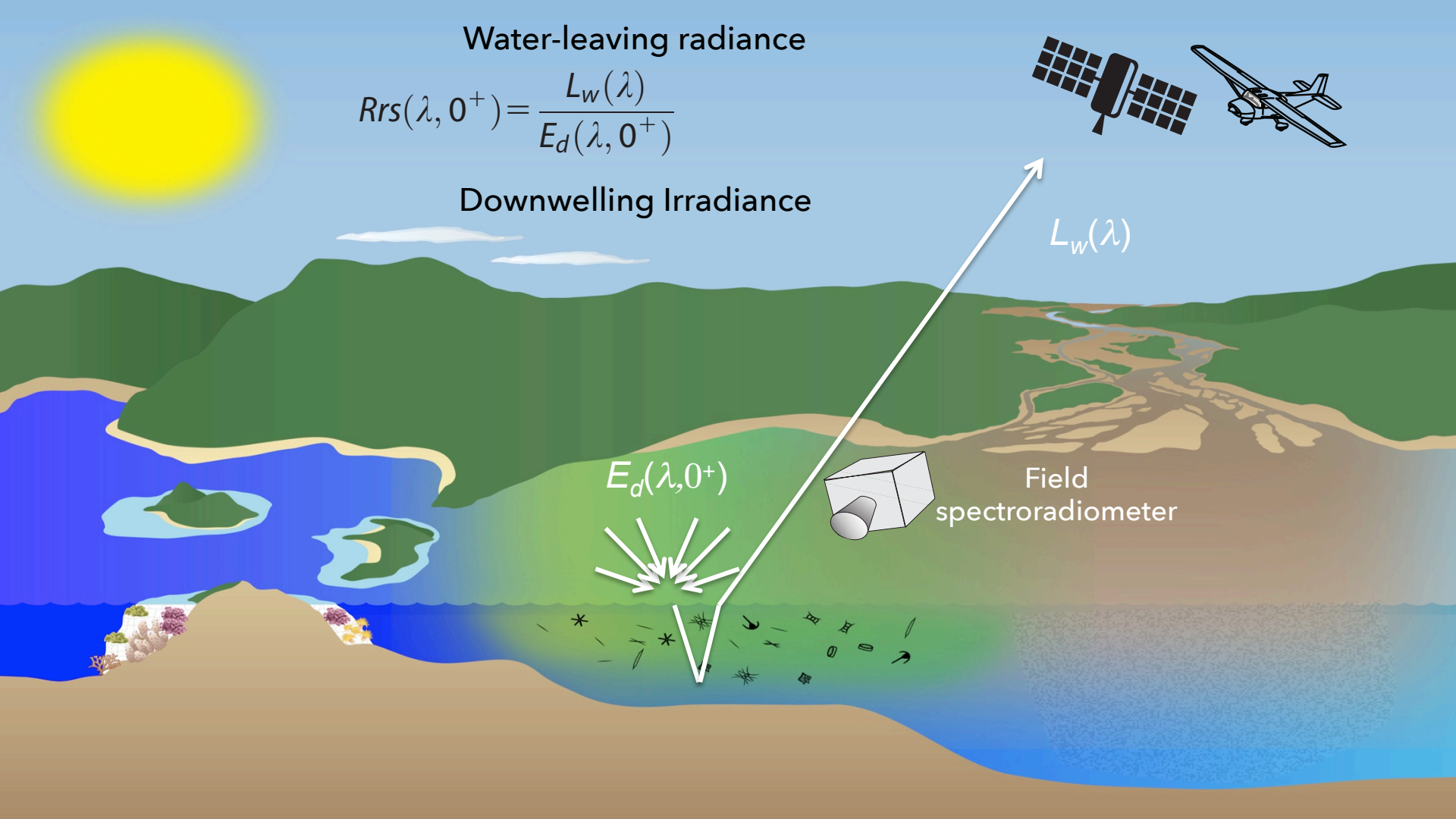
In Situ Observations Required



Water-leaving radiance

$$Rrs(\lambda, 0^+) = \frac{L_w(\lambda)}{E_d(\lambda, 0^+)}$$

Downwelling Irradiance



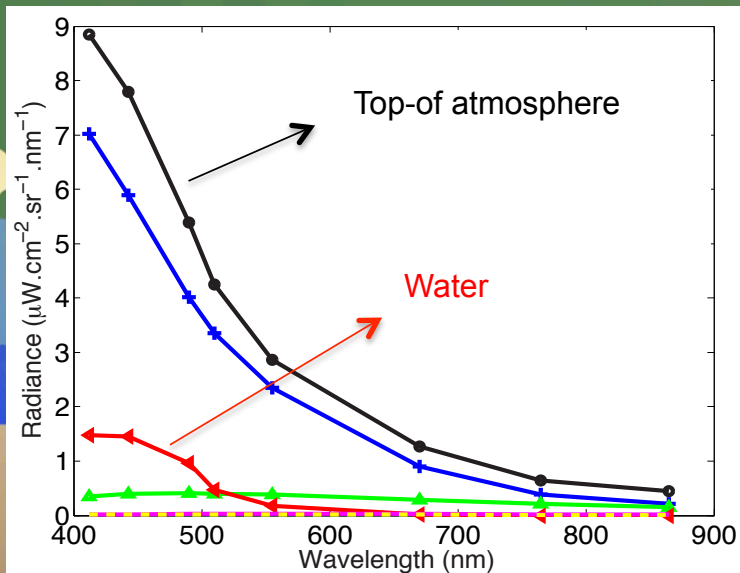
Atmospheric Correction



$$L_t(\lambda) = L_r(\lambda) + L_a(\lambda) + L_{ra}(\lambda) + T(\lambda, \theta)L_g(\lambda) + t(\lambda, \theta)L_{wc}(\lambda) + t(\lambda, \theta)L_w(\lambda)$$

>90%

<10%



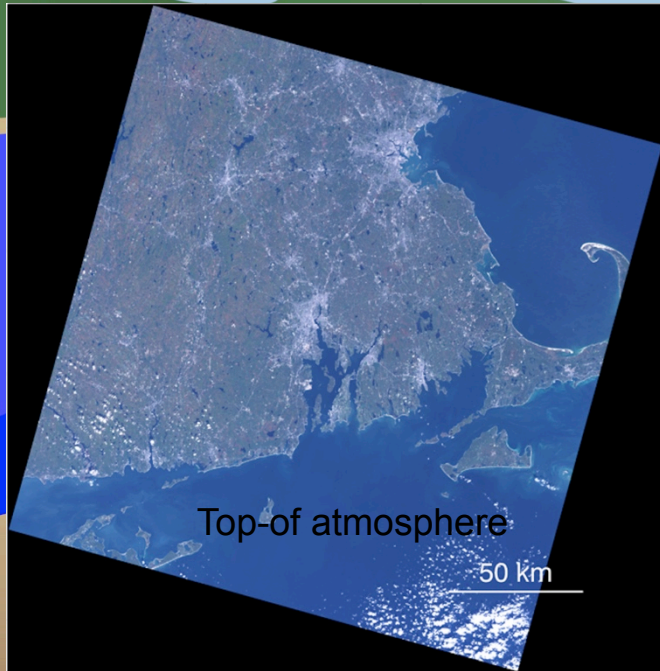
Atmospheric Correction



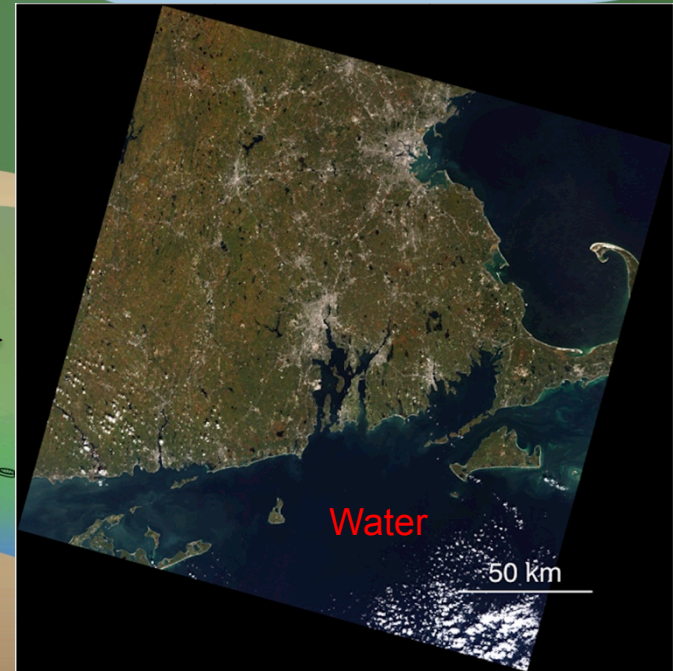
$$L_t(\lambda) = L_r(\lambda) + L_a(\lambda) + L_{ra}(\lambda) + T(\lambda, \theta)L_g(\lambda) + t(\lambda, \theta)L_{wc}(\lambda) + t(\lambda, \theta)L_w(\lambda)$$

>90%

<10%



Atmospheric
correction



A satellite image of a coastal region. In the top left, a river with a complex delta system flows into a body of water. The land is green with some brown patches, indicating vegetation and possibly agricultural or natural terrain. The water transitions from a light turquoise near the shore to a deep blue further out. A semi-transparent white rectangular box is overlaid on the right side of the image, containing the title text.

Satellites and Sensors for Water Quality

Overview of NASA Satellites & Sensors for Water Quality Monitoring

- Currently several satellites observe water surface properties in:
 - Coastal oceans and estuaries
 - Many in-land lakes
- A number of WQ parameters are operationally available from these satellites
 - Temperature
 - Chl-a

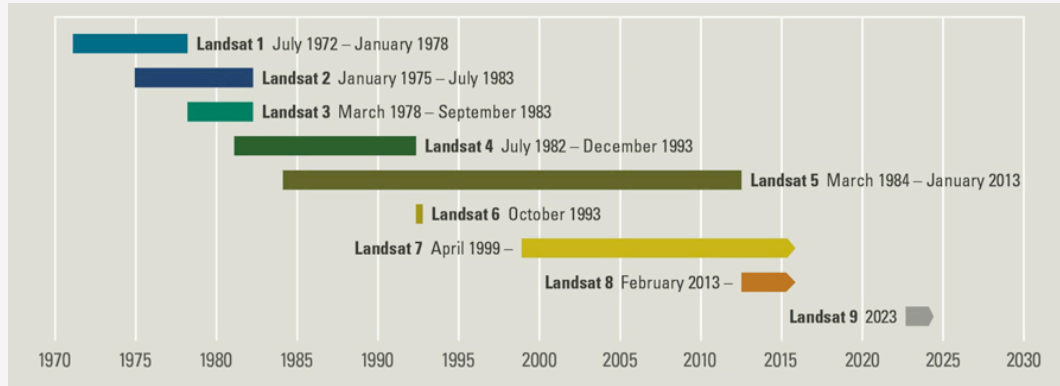


Overview of NASA Satellites & Sensors for Water Quality Monitoring

Satellite	Sensor	Parameter
Landsat Series (7/1972 - present)	<ul style="list-style-type: none"> Thematic Mapper (TM) Enhanced Thematic Mapper (ETM+) Operational Land Imager (OLI) 	<ul style="list-style-type: none"> Spectral Reflectance
Terra (12/1990-present)	Moderate Resolution Imaging Spectroradiometer (MODIS)	<ul style="list-style-type: none"> Spectral Reflectance Chlorophyll-a Concentration Temperature Colored Dissolved Organic Matter (CDOM) Turbidity Euphotic Depth
Aqua (5/2002-present)		
Terra (12/1999 – present)	Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	<ul style="list-style-type: none"> Spectral Reflectance Temperature
National Polar Partnership (NPP) (11/2011-present)	Visible Infrared Imaging Radiometer Suite (VIIRS)	<ul style="list-style-type: none"> Spectral Reflectance Chlorophyll Concentration

Landsat Satellites and Sensors

<http://landsat.gsfc.nasa.gov>



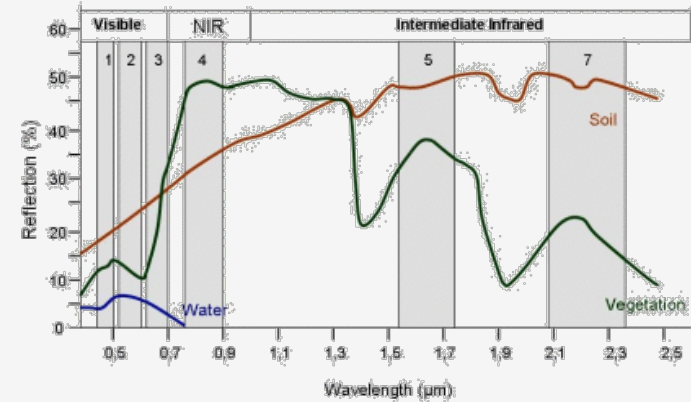
http://landsat.usgs.gov/about_mission_history.php

- Near-polar orbit, 10 a.m. equator-crossing time
- Global coverage
- July 1972 – Present
 - 16 day revisit time
- Sensors
 - MSS
 - TM
 - ETM+
 - OLI
 - TIRS

Enhanced Thematic Mapper (ETM+)

<http://geo.arc.nasa.gov/sge/landsat/l7.html>

- Flying on-board Landsat-7 polar orbiting satellites
- Spatial Coverage and Resolution:
 - Global, swatch: 185km
 - Spatial resolution: 15m, 30m, 60m
- Temporal Coverage and Resolution
 - April 15, 1999 – present
 - 16 day revisit time

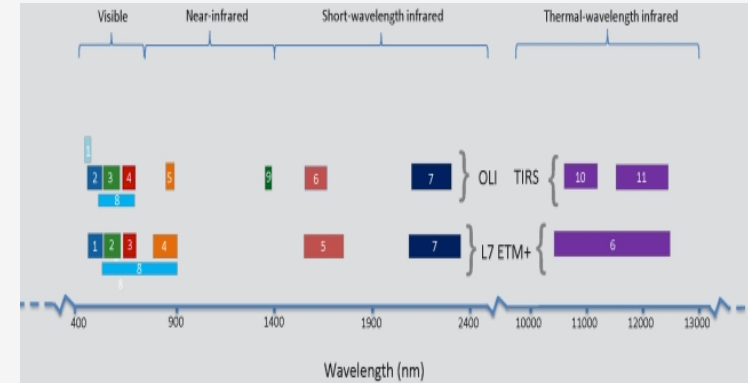


- **Spectral Bands: 8**
 - Major bands include: blue-green, green, red, reflected and thermal IR, panchromatic
- Bands 1-5 & 7: 30m
- Band 6: 60m
- Band 8: 15m

Operational Land Imager (OLI)

<http://landsat.usgs.gov/landsat8.php> and <http://landsat.gsfc.nasa.gov/?p=5779>

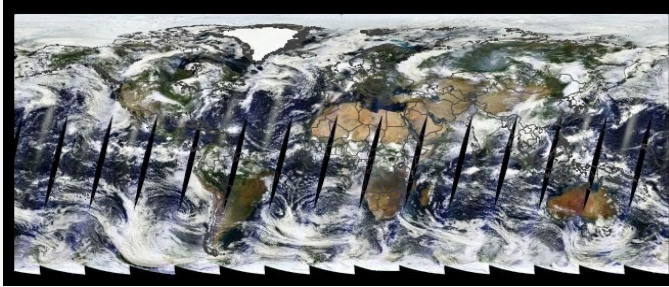
- Flying on-board Landsat-8 polar orbiting satellite
 - Landsat Data Continuity Mission (LDCM)
- Spatial Coverage and Resolution
 - Global, swath 185km
 - Spatial resolution: 15km, 30m
- Temporal Coverage and Resolution
 - February 11, 2013 – present
 - 16 day revisit time



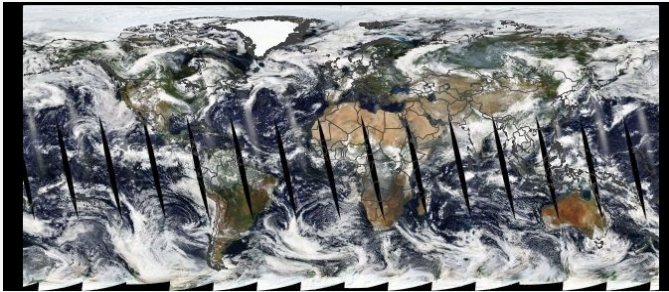
- **Spectral Bands: 9**
 - Major bands include blue-green, red, near IR, shortwave and thermal IR, panchromatic
- Bands 1-7 & 9: 30m
- Band 8: 15m

Terra and Aqua

<http://terra.nasa.gov>



<http://aqua.nasa.gov/>



Terra:

- Polar orbit, 10:30 am equator crossing time
- Global Coverage
- December 18, 1999 – Present
- 1-2 observations per day

Sensors:

ASTER, CERES, MISR, MODIS, MOPITT

Aqua:

- Polar orbit, 1:30 pm equator crossing time
- Global Coverage
- May 4, 2002 – Present
- 1-2 observations per day

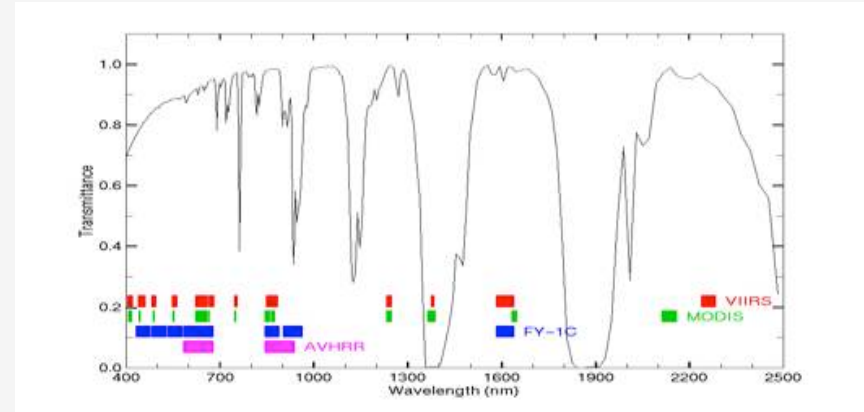
Sensors:

AIRS, AMSU, CERES, MODIS, AMSR-E

MODerate Resolution Imaging Spectroradiometer (MODIS)

<http://modis.gsfc.nasa.gov>

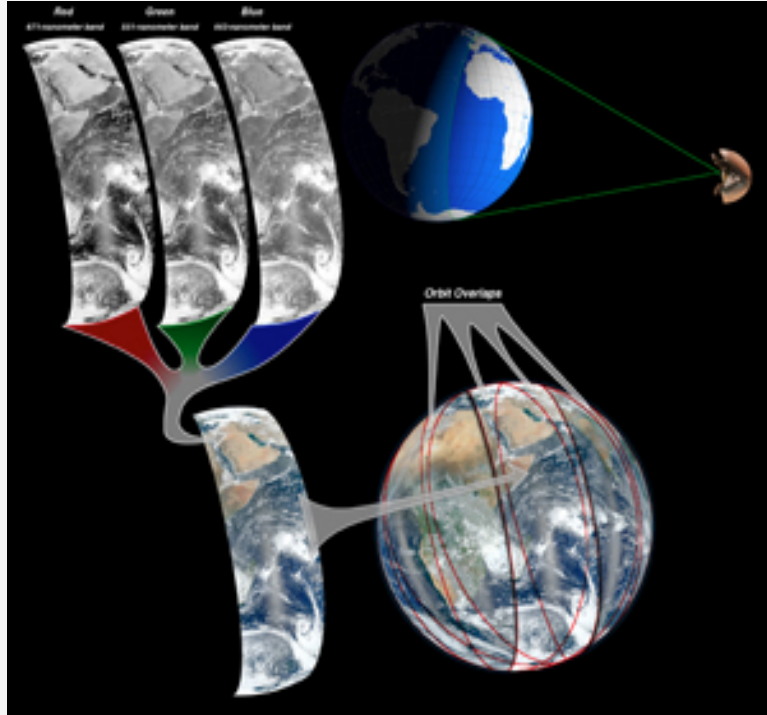
- Flying on-board Terra & Aqua polar orbiting satellites
 - Designed for land, atmosphere, ocean and cryosphere observations
- Spatial Coverage and Resolution
 - Global, swath width: 2330 km
 - Spatial resolution varies: 250m, 500m, 1km
- Temporal Coverage and Resolution
 - 2000-present, 2 times per day



- **Spectral Bands: 36**
 - Major bands includes red, blue, IR, NIR, MIR
- Bands 1-2: 250m
- Bands 3-7: 500m
- Bands 8-36: 1000m

National Polar Partnership (NPP)

http://www.nasa.gov/mission_pages/NPP

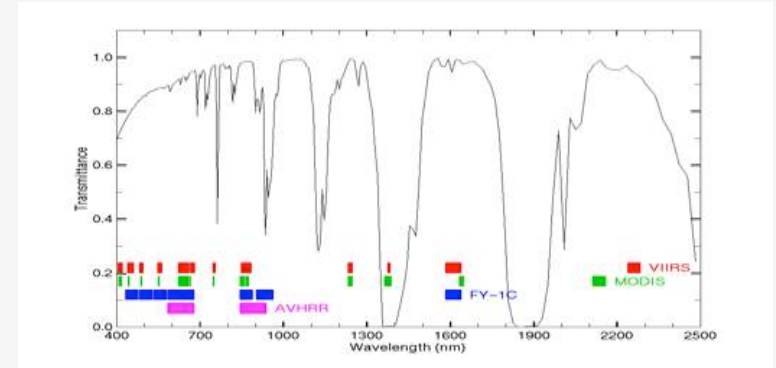


- Polar Orbit, 1:30 p.m. equator crossing time
- Global coverage
- November 21, 2011- present
 - 1-2 observations per day
- Sensors
 - VIIRS
 - ATMS
 - CrIS
 - OMPS
 - CERES


Visible Infrared Imaging Radiometer Suite (VIIRS)

<http://npp.gsfc.nasa.gov/viirs.html>

- Flying on-board NPP – polar orbiting satellite
 - Designed to collect measurements of clouds, aerosols, ocean color, surface temperature, fires, and albedo
- Spatial Coverage and Resolution
 - Global, swatch width: 3040km
 - Spatial resolution: 375m to 750m
- Temporal Coverage and Resolution
 - October 2011-present
 - 2 times per day



- **Spectral Bands: 15**
 - Major bands include visible, red, blue, green, short, middle, and long-wave IR
- Ocean color bands 1-7
 - 0.402 – 0.682 μm
- Sea surface temperature bands 12-13
 - 3.660 – 4.128 μm

A satellite image of a coastal region, likely the Amazon River delta, showing a complex network of green land, light brown sediment-filled channels, and deep blue ocean water. A semi-transparent white rectangular box is overlaid on the right side of the image, containing the title text.

WQ Data and Demonstration of Web Tools - Giovanni and OceanColor Web Visualize and Access the Data

Water Quality Data

Satellite	Sensor	Parameter
Landsat Series (7/1972 - present)	<ul style="list-style-type: none"> • Thematic Mapper (TM) • Enhanced Thematic Mapper (ETM+) • Operational Land Imager (OLI) 	<ul style="list-style-type: none"> • Spectral Reflectance
Terra (12/1990-present)	Moderate Resolution Imaging Spectroradiometer (MODIS)	<ul style="list-style-type: none"> • Spectral Reflectance • Chlorophyll-a Concentration • Temperature • Colored Dissolved Organic Matter (CDOM) Index • Turbidity • Euphotic Depth
Aqua (5/2002-present)		
Terra (12/1999 – present)	Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	<ul style="list-style-type: none"> • Spectral Reflectance • Temperature
National Polar Partnership (NPP) (11/2011-present)	Visible Infrared Imaging Radiometer Suite (VIIRS)	<ul style="list-style-type: none"> • Spectral Reflectance • Chlorophyll Concentration

Levels of Data

Level 0 Raw Instrument Data



Level 1 Geolocated and Calibrated



Level 2 Geophysical Data Product
Derived from L1 Data



Level 3 Composites of Level 2 Data
Products

Level 4 Model-derived Data Product

- **Orbital Data (Levels 0, 1, 2)**

- More user control
- Highest spatial/temporal resolution
- Harder to use

- **Gridded Data Products (Levels 3, 4)**

- Less user control
- Lower spatial/temporal resolution but gridded and may be available at multiple spatial/temporal resolutions
- More web tools available for analysis/access
- Easier to use

Water Quality Access Tools

Satellite/Sensor	Data Access Tool	Source	Coverage	Spatial Resolution
Terra and Aqua: MODIS WQ Parameters	Giovanni Seadas/Oceancolor Web	NASA Goddard Earth Sciences, Data & Information Services Center	8-day and monthly Composites 2000-present	9 km and 4 km
MODIS : Level 1 & 2 Data Level 3 Data	OceanColor Web	NASA	Daily Daily, 3 and 8 day Composites, Monthly, Seasonal 2000-present	250 m 9 km and 4 km
Landsat* Tm, ETM+ EO-1/Hyperion Terra/ASTER Spectral Reflectance	LandsatLook Viewer* GloVIS EarthEXplorer	USGS	July 1972-present	30 -60 m (Landsat and EO1-) 15 m (ASTER)
NPP/VIIRS WQ Parameters	STAR	NOAA	October 2011-present	375 m

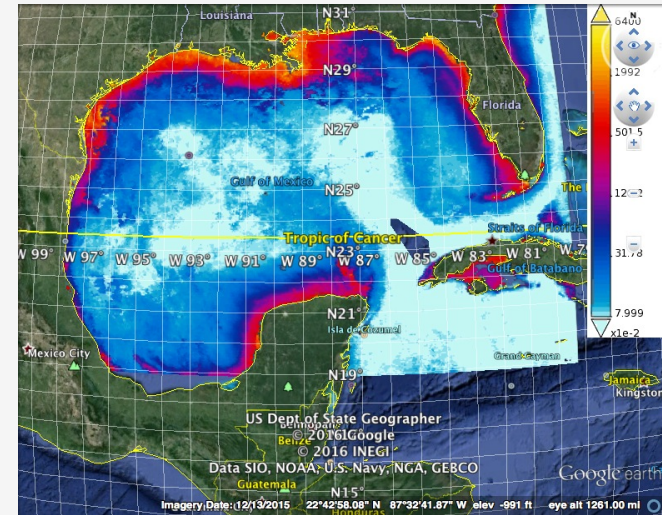
Giovanni

<http://giovanni.gsfc.nasa.gov/giovanni>

- Giovanni:
 - **G**eospatial **I**nteractive **O**nline **V**isualization **A**nd **a**nalYsis **I**nfrastructure
- A web-based application developed by the Goddard Earth Sciences Data & Information Services Center (GES DISC)
- Provides a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data without having to download the data


- **Available Data:**

- MODIS-Aqua Chlorophyll Concentration Monthly, 4km (7/2002 – 2/2016)



Giovanni – User Selections

<http://giovanni.gsfc.nasa.gov/giovanni>

 **EARTHDATA** Data Discovery ▾ DAACs ▾ Community ▾ Science Disciplines ▾

GIOVANNI The Bridge Between Data and Science v 4.12 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

GOCART data no longer available... [1 of 1 messages] [Read More](#)

Select Plot

☒ Maps: Time-Averaged ▾

☐ Comparisons: Select... ▾

☐ Time Series: Select... ▾

☐ Vertical: Select... ▾

☐ Miscellaneous: Select... ▾

Select Date Range (UTC)

YYYY-MM-DD.

HH:mm

- -  00 : 00 to - -  23 : 59

Valid Range: 1979-01-01 to 2015-04-08

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North

-180, -90, 180, 90

Show Map

Show Shapes

Select Variables

▼ Disciplines

- ☐ Aerosols (117)
- ☐ Atmospheric Chemistry (18)
- ☐ Atmospheric Dynamics (64)
- ☐ Hydrology (114)
- ☐ Water and Energy Cycle (120)

▼ Measurements

- ☐ Aerosol Index (1)
- ☐ Air Pressure (6)
- ☐ Air Temperature (15)
- ☐ Albedo (8)
- ☐ Altitude (4)
- ☐ Angstrom Exponent (16)
- ☐ Atmospheric Moisture (23)
- ☐ CH4 (4)
- ☐ CO (4)

Number of matching Variables: 0 of 331

Total Variable(s) included in Plot: 0

Keyword :

Search

Clear

Search Data by a Keyword

Analysis and
Plot Selection

Start and End Date; and
Spatial Selection by
Map/Latitude-Longitude/
Shapefile

Giovanni – User Selections

<http://giovanni.gsfc.nasa.gov/giovanni>

MODIS-based Chlorophyll Concentration for February 2016 in the Great Lakes

Select Plot

☒ Maps: Time Averaged Map ☐ Comparisons: Select... ☐ Time Series: Select... ☐ Vertical

Select Date Range (UTC)

YYYY-MM HH:mm 2016 -02 -01 00:00 to 2016 -02 -29 23:59 Valid Range: 2002-07-04 to 2016-02-29

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North -92.9883, 39.7852, -75.7617, 53.14 Show Map

Select Variables

▼ Disciplines

- ☐ Ocean Biology (1)
- ☐ Oceanography (2)

▼ Measurements

- ☐ Chlorophyll (2)

► Platform / Instrument

► Spatial Resolutions

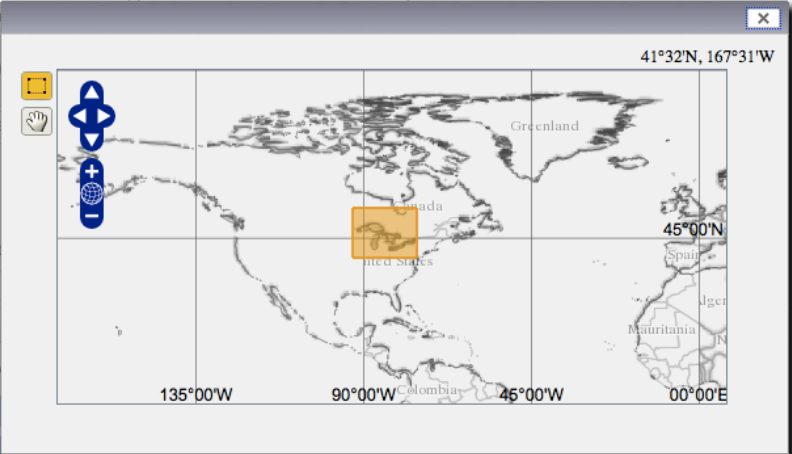
► Temporal Resolutions

► Portal

Number of matching Variables: 2 of 1239 Total Variable(s) included in Plot

Keyword: MODIS Chlorophyll

	Variable	Source
<input type="checkbox"/>	Normalized fluorescence line height (MODISA L3m_FLH v2014)	MODIS-A
<input checked="" type="checkbox"/>	Chlorophyll a concentration (MODISA L3m_CHL v2014)	MODIS-A



Giovanni – Visualization

<http://giovanni.gsfc.nasa.gov/giovanni>

1. Time Averaged Map

Time Averaged Map of Chlorophyll a concentration monthly 4 km [MODIS-Aqua MODISA_L3m_CHL v2014] n
over 2016-01-31 22:35:09Z - 2016-03-31 02:35:08Z, Region 92.9883W, 39.7852N, 75.7617W, 53.1445N

Zoom
In

Save Image

Download
Data

Download As...
GEOTIFF
KMZ
PNG

History

• 1. Tim

- 1. Tim
- Plot Options
- Downloads
- Lineage

Map Options

Time Averaged Map of Chlorophyll a concentration monthly 4 km
[MODIS-Aqua MODISA_L3m_CHL v2014] mg m-3

Change Data Range

Minimum: 0.07999

Maximum: 64

Change Palette

- ☒ Cyan-Red-Yellow (Seq), 65
- ☐ Greys, Dark to Light (Seq), 9
- ☐ Greens (Seq), 9
- ☐ Blue-Yellow-Red (Div), 12
- ☐ Blue-Green-Yellow (Seq), 9

View All Palettes

Change Smoothing

☐ On ☒ Off

Change Scaling

☐ Linear ☒ Log

Restore Defaults

Re-Plot

Change Colors and Re-plot

Giovanni – Data Download

<http://giovanni.gsfc.nasa.gov/giovanni>

The screenshot shows the 'MODIS Collection 6...' page with a '1. Time Averaged Map' section. A red arrow points from a yellow box 'Options for multiple formats, including GeoTIFF for GIS' to the 'g4.timeAvgMap.MODISA.L3m.CH1.2014.ch1a.20160201-20160229.92W_39N_75W_53N.kmz' link. Another yellow box 'Click to download the files' is positioned above the links. A third yellow box 'Back to Data Selection' has a red arrow pointing to the 'Back to Data Selection' button in the footer. The footer also contains the NASA logo, contact information, and logos for NC, OPeNDAP, and ECHO.

MODIS Collection 6... [1 of 1 messages] [Read More](#)

1. [Time Averaged Map](#)

Click on file links to download. Files contain data portrayed in the plot images.

NetCDF:
[g4.timeAvgMap.MODISA.L3m.CH1.2014.ch1a.20160201-20160229.92W_39N_75W_53N.nc](#)

PNG:
[g4.timeAvgMap.MODISA.L3m.CH1.2014.ch1a.20160201-20160229.92W_39N_75W_53N.png](#)

GEOTIFF:
[g4.timeAvgMap.MODISA.L3m.CH1.2014.ch1a.20160201-20160229.92W_39N_75W_53N.geotiff](#)

KMZ:
[g4.timeAvgMap.MODISA.L3m.CH1.2014.ch1a.20160201-20160229.92W_39N_75W_53N.kmz](#)

History

- 1. [Time Averaged Map](#)
 - [User Input](#)
 - [Plots](#)
 - [Plot Options](#)
 - [Downloads](#)
 - [Lineage](#)

Options for multiple formats, including GeoTIFF for GIS

Click to download the files

Back to Data Selection

Responsible NASA Official: Steven.J.Kempler@nasa.gov
Web Curator: M.Hegde@gsfc-help-disc@lists.nasa.gov
[Privacy Policy and Important Notices](#)

Powered By: NC OPeNDAP ECHO

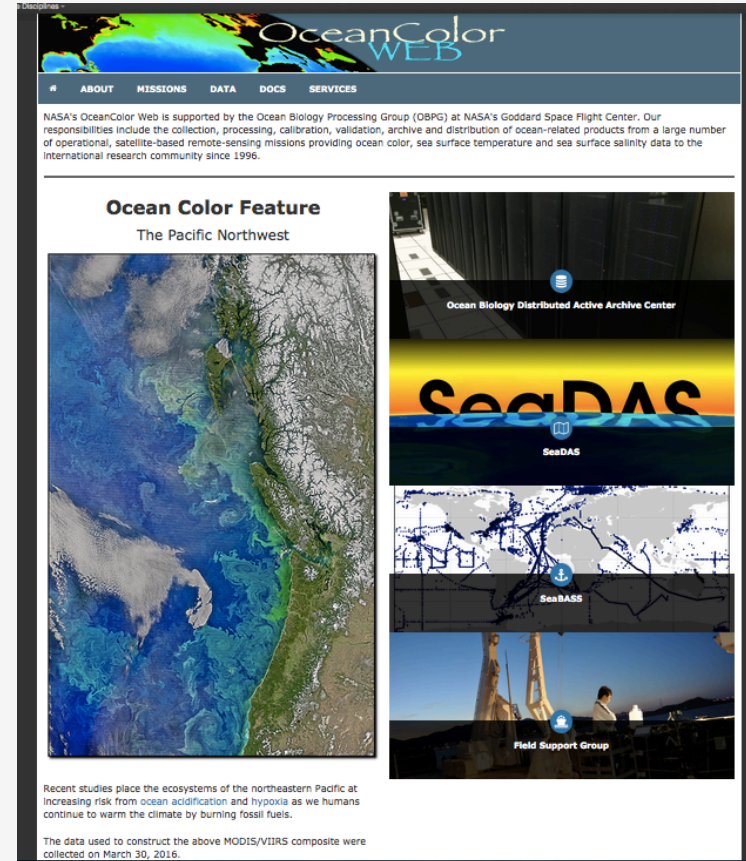
[Contact Us](#)

[Acknowledgment Policy](#) [Help](#) [Feedback](#) [Back to Data Selection](#)

OceanColor Web

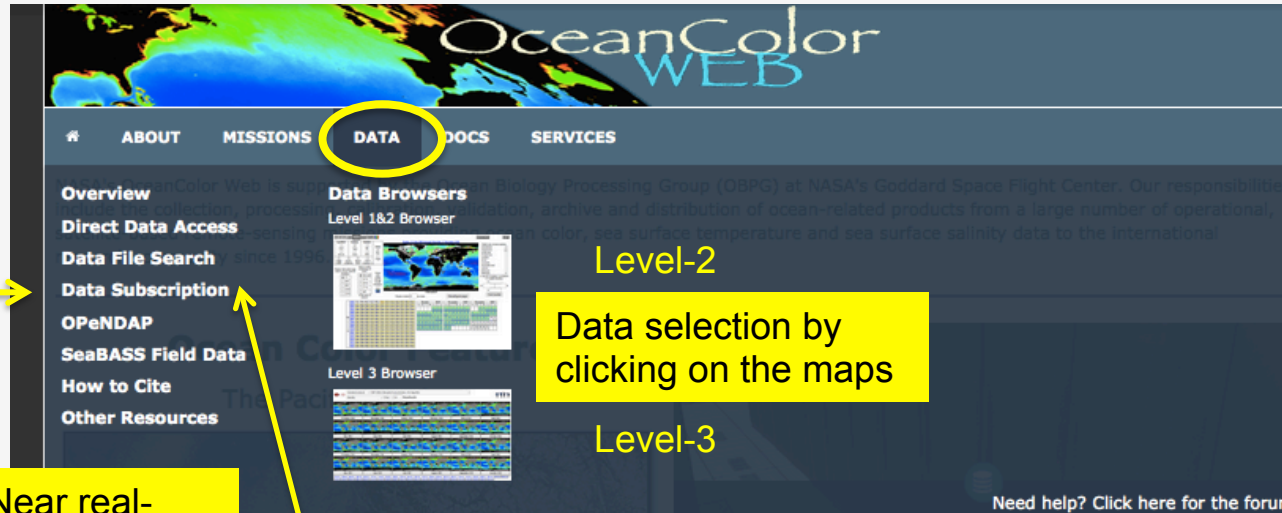
<http://oceancolor.gsfc.nasa.gov/cms>

- Developed for collection, processing, validation, and distribution of ocean-related products from remote sensing and in situ observations
- Useful for monitoring coastal and in-land water bodies and estuaries
- Provides visual data browsing capability for L1/L2 and L3 data [Chlorophyll Concentration- Chl, Sea Surface Temperature- SST] from selected sensors, and advance capability of processing remote sensing images by using SeaDAS



OceanColor Web - Data Visualization and Data Access

<http://oceancolor.gsfc.nasa.gov/cms>



Available Missions

Ancillary

Aquarius *

CZCS*

HICO *

MERIS *

MODIS-Aqua

MODIS-Terra

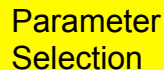
OCTS *

SeaWiFS*

VIIRS

* Past Missions

<http://oceancolor.gsfc.nasa.gov/cms>



Zoom on a Region

MODIS and VIIRS Near Real-Time and Past Chlorophyll Data

SeaWiFS	MODIS of	MERIS
<input type="checkbox"/> GAC	<input type="checkbox"/> Aqua	<input type="checkbox"/> RSR
<input type="checkbox"/> MLAC	<input type="checkbox"/> Terra	<input type="checkbox"/> FRS

<input type="checkbox"/> VIIRS (Suomi-NPP)	<input type="checkbox"/> OCTS (ADEOS)	<input type="checkbox"/> HICO (ISS)	<input type="checkbox"/> CZCS (Nimbus-7)
-----------------------------------------------	------------------------------------------	----------------------------------------	---------------------------------------------

☒ Select
☐ Day
☐ Night

Select swaths containing *(at least):*

<input checked="" type="radio"/> any part
<input type="radio"/> 25 %
<input type="radio"/> 50 %
<input type="radio"/> 75 %
<input type="radio"/> all

☐ Select one or more regions:

AdriaticSea
 AegeanSea
 Antarctica
 ArabianSea
 AralSea
 Arctic
 Australia
 AustralaCoast
 Azores
 Bahamas
 BalticSea

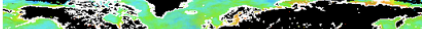
or specify boundary coordinates or a single location:

N:

E:

W:

S:



Chlorophyll

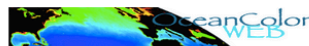
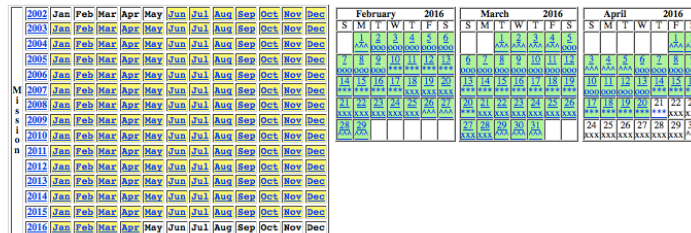
Display results 10 at a time.

Pre-defined Regions

Area and Swath Size Selections

Time Selection
(Year)

Time Selection (Month and Day)

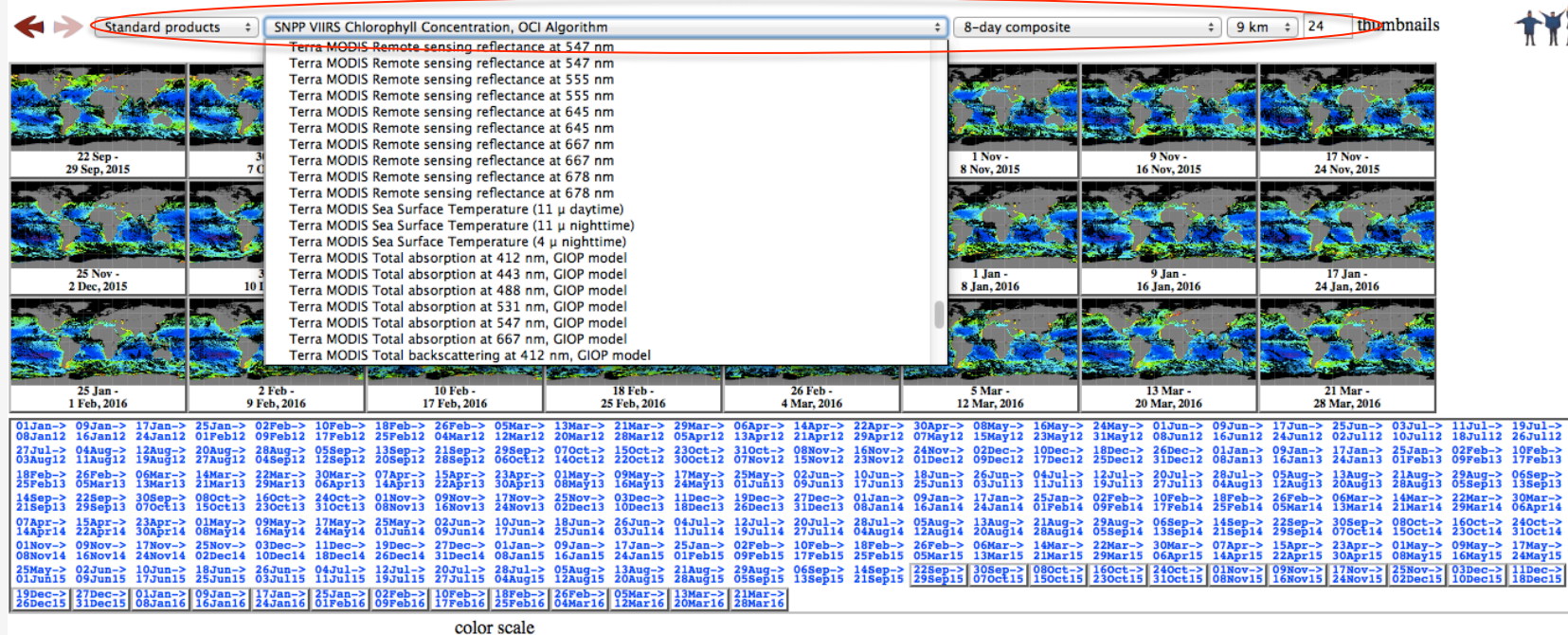


gene carl feldman (gene.c.feldman@nasa.gov) (301) 286-9428

OceanColor Web: L3 Data Visualization

<http://oceancolor.gsfc.nasa.gov/cms>

Data Product, Time Selections, and Spatial Resolution Selections



SeaDAS: Data Analysis Package

<http://seadas.gsfc.nasa.gov/>

- SeaDAS is a comprehensive image analysis package developed for the processing, display, analysis, and quality control of ocean color data.
- The latest version (SeaDAS 7.3.1) is developed in a collaboration with the developers of ESA's BEAM software package.

OceanColor SeaDAS

Missions Data Documents Analyses People Forum Services Links

SeaDAS

General Description

SeaDAS is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data. While originally developed to support the SeaWiFS mission, it now supports most US and international ocean color missions. The primary focus of SeaDAS is ocean color data, but it is applicable to many satellite-based earth science data analyses.

The latest version (SeaDAS 7.3.1) is the result of a collaboration with the developers of ESA's BEAM software package. The core visualization package for SeaDAS 7 is based on the BEAM framework, with extensions that provide the functionality provided by previous versions of SeaDAS.

Features Requirements Download

Supported Missions	User Support	Other
<ul style="list-style-type: none">MODISSeaWiFSCZCSVIIRSHICOAquariusLandsat8/OLI	<ul style="list-style-type: none">MERISOCTSOCMOCM-2OSMIMOSGOCI	<ul style="list-style-type: none">SeaDAS Video Tutorials and DemosSeaDAS FAQSeaDAS Help PagesOther SeaDAS Tutorial MaterialOcean Color WebOcean Color ForumSeaDAS Mailing List

Curator: OceanColor Webmaster
Authorized by: gene carl feldman

Privacy Policy and Important Notices
Updated: 24 February 2016

NASA

SeaDAS: Features

<http://seadas.gsfc.nasa.gov/>

SeaDAS Features

Visualization

- Very fast image display and navigation even of giga-pixel images
- Advanced layer management allows adding and manipulation of new overlays such as images of other bands, images from WMS servers or ESRI shapefiles
- Rich region-of-interest definitions for statistics and various plotting functions
- Easy bitmask definition and overlay
- Flexible band arithmetic using arbitrary mathematical expressions
- Accurate reprojection and ortho-rectification to common map projections
- Geo-coding and rectification using ground control points
- Coastline, land/water masking for navigated data
- Store and restore the current session including all opened files, views and layers

Data Processing

SeaDAS offers the ability for users to process satellite data from a number of ocean color missions (both U.S. and International) through the various processing levels:

- Level 0 to Level 1 processing is offered for the MODIS sensors onboard the Terra and Aqua spacecraft
- Level 1 to Level 2 (l2gen)
- Level 2 to Level 3 binned (l2bin)
- Temporal binning of Level 3 (l3bin)
- Mapping of Level 1 data (l1mapgen)
- Mapping of Level 2 data (l2mapgen)
- Mapping of Level 3 binned data (smigen)
- Browse file creation (l1brsgen, l2brsgen)

SeaDAS: System Requirement

<http://seadas.gsfc.nasa.gov/>

- Visualization-only version
- Visualization and data processing version
- Multiple mission data can be analyzed
- SeaDAS download, installation, and usage require advance training

SeaDAS Configuration and Requirements

SeaDAS is currently available for Linux, Mac OS X, and Windows. The Windows version currently does not support the science data processing code. The SeaDAS [source code](#) is publicly available.

Suggested Hardware Requirements:

Platforms:	Linux Intel Mac OS X
Memory:	256MB minimum, 1GB+ suggested
Disk:	SeaDAS software package (display only version): ~200MB SeaDAS software package (with processing capabilities for all sensors): ~5GB 10GB of free space is also suggested for rudimentary data processing and storage.
Display:	15" Console or X-terminal with 20MB memory 1280x1024 resolution 24-bit X display plane depth 256 colors display minimum

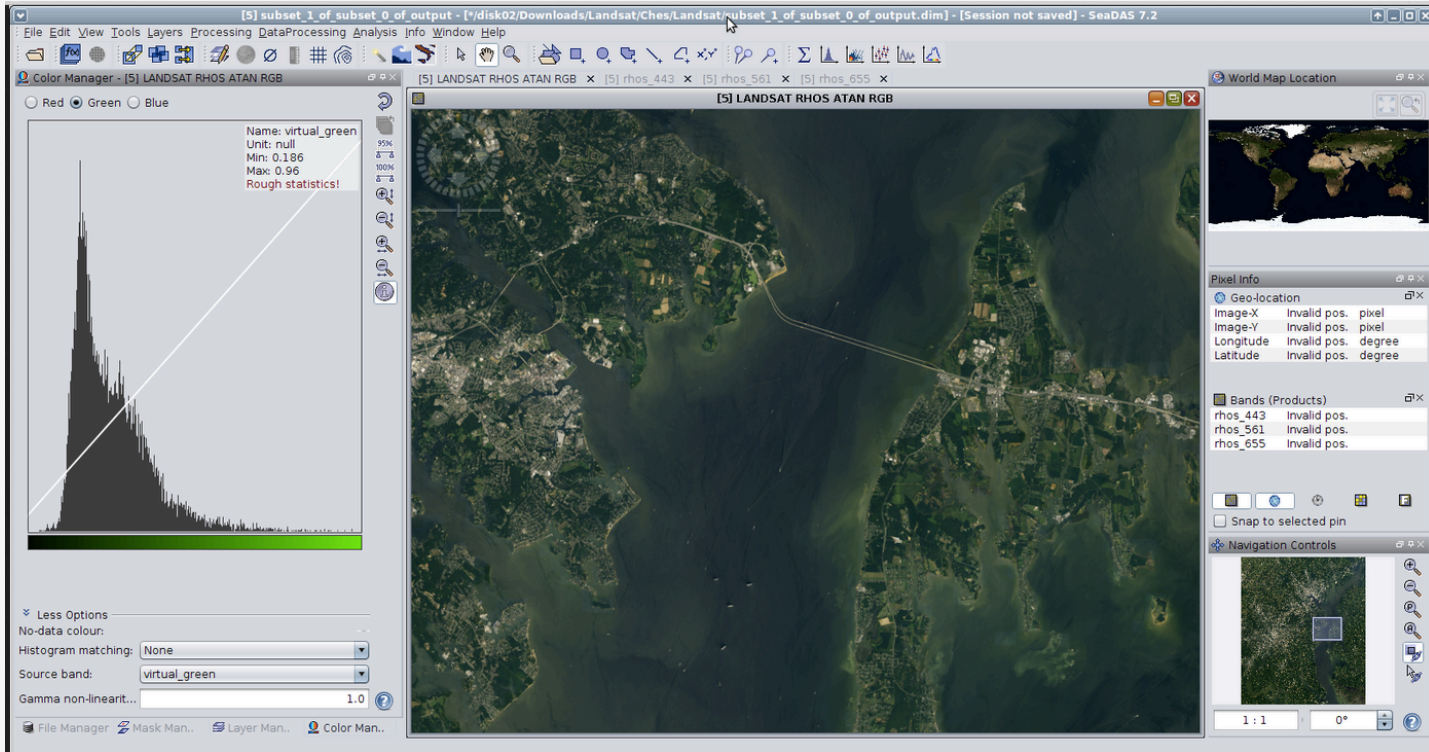
Requirements:

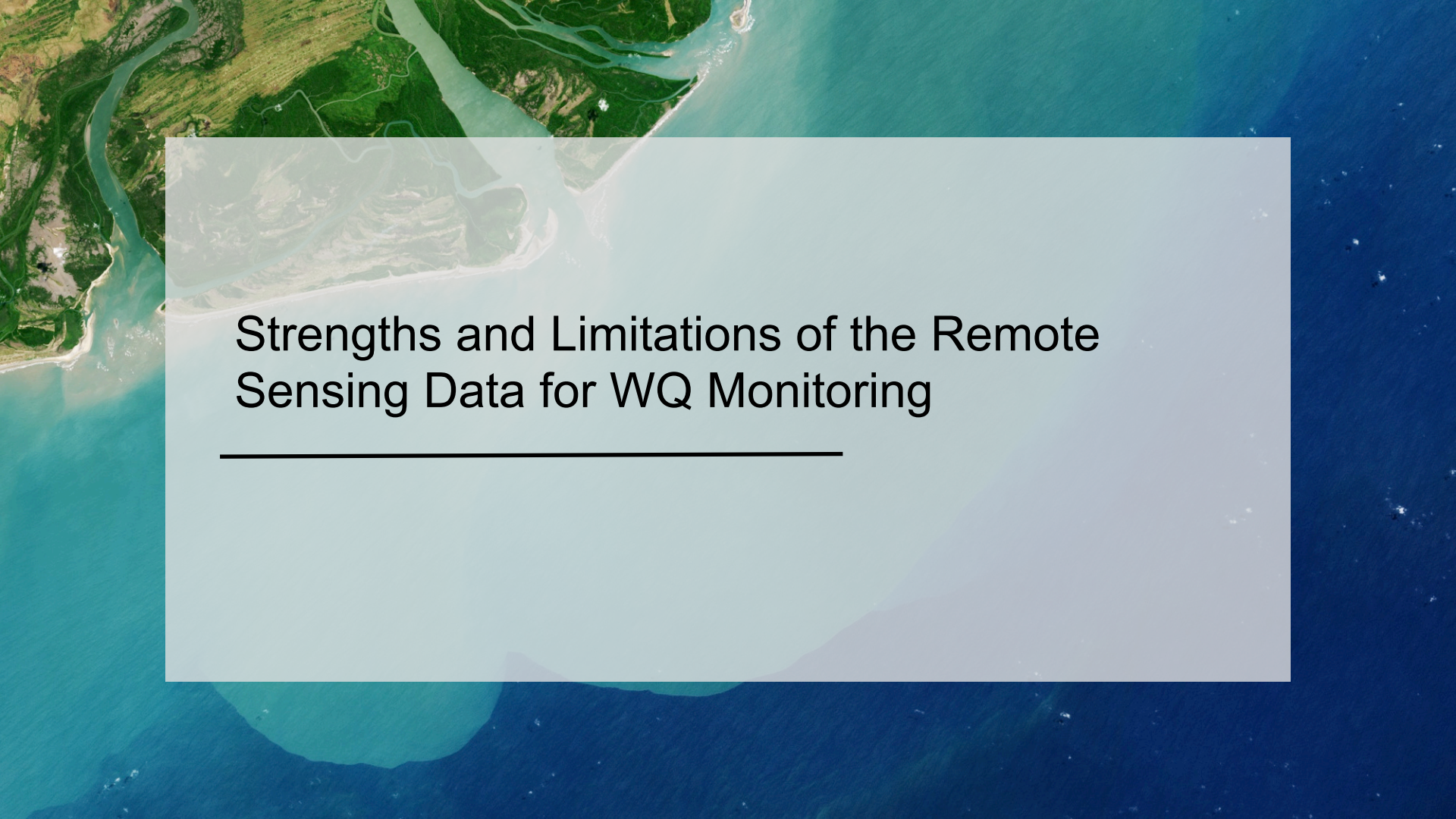
The core visualization package of SeaDAS is written in Java. A minimum Java JRE of version 1.7 is required. A suitable JRE is packaged with the Windows and MacOSX distributions. Linux users will need to separately install a suitable JRE.

Operating Systems:	Linux: tested on various versions of CentOS, Fedora, and Ubuntu Intel Mac: OS X 10.10	
Optional Compilers:	gcc/g++/gfortran (version 4.5 or higher) or Intel Compilers	
Program	Version	Notes
Java	JRE 1.7 or above	Windows and MacOSX distributions come with a suitable JRE Linux users will need to separately install a suitable JRE
Bash	4.x	version 3.x should work, but not tested necessary only for science code, thus not required for Windows distributions
Python	2.6.5 or above	necessary only for science code, thus not required for Windows distributions; not (yet) compatible with version 3 and above
Git	1.7.9 or above	necessary only for science code install/update option, thus not required for Windows distributions
cURL	7.x or above	necessary only for science code install/update option, thus not required for Windows distributions

SeaDAS: Example

<http://seadas.gsfc.nasa.gov/>



An aerial photograph of a coastal region. A river with a complex delta system flows from the top left towards the center. The water in the delta is a light, milky turquoise color, contrasting with the deeper blue of the open ocean on the right. The land is green with some brown patches, indicating vegetation and possibly exposed sediment. A semi-transparent white rectangular box is overlaid on the right side of the image, containing the title text.

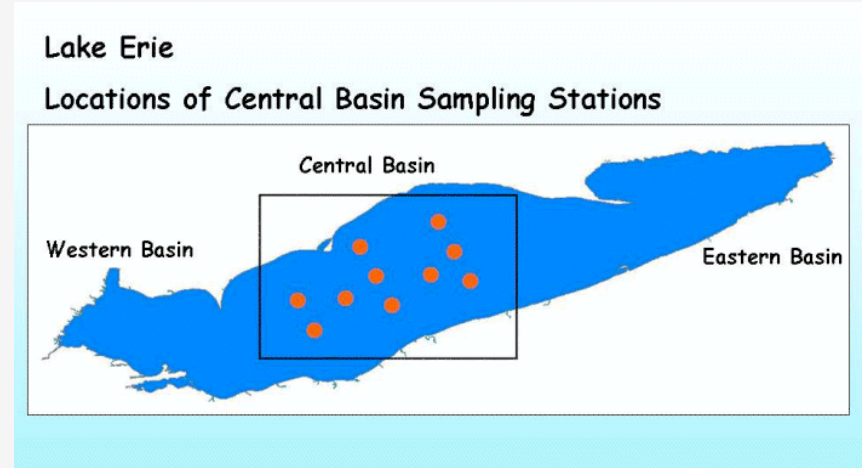
Strengths and Limitations of the Remote Sensing Data for WQ Monitoring

Remote Sensing Observations: Trade Offs

- It is difficult to obtain extremely high spectral, spatial, temporal and radiometric resolution at the same time
- Several sensors can obtain global coverage every one to two days because of their wide swath width (for example, MODIS on Terra/Aqua) but have spatial resolution of 250 m to 1 km
- Higher spatial resolution (30 m) polar orbiting satellites (for example, Landsat) have lower temporal resolution of 16 days
- Large amount of data with varying formats
- Data applications may require additional *in situ* measurements, processing, visualization and other tools

Limitations of In Situ Observations for Water Quality Monitoring

- In situ measurements have limited sample collection – not representative of entire water body
- Periodic sample collection may not capture daily, monthly, or seasonal water quality changes
- Labor intensive and expensive

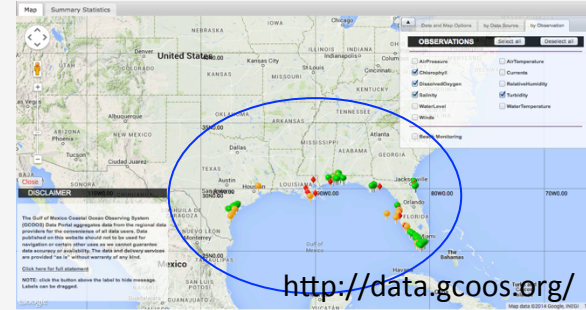


<http://epa.gov/greatlakes/monitoring/>

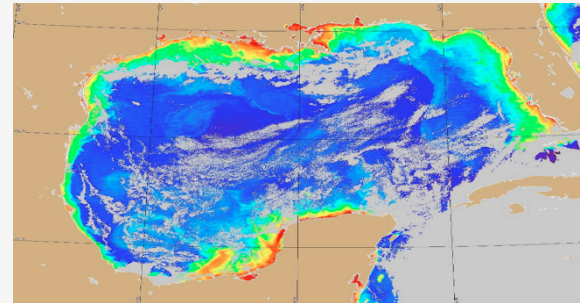
Advantage of Remote Sensing Observations for Water Quality Monitoring

- Provides information where there are no surface-based measurements available and augments when available
- Provides global/near-global coverage with consistent observations
- Provides continuous coverage in comparison to point measurements

Limited Water Sampling Locations



MODIS Aqua satellite image from October 23, 2011, showing areas of elevated chlorophyll a (in red and orange)



| Limitations of Remote Sensing Observations for Water Quality Monitoring

- Spectral reflectance in the presence of clouds may be unsuitable for monitoring WQ
- Atmospheric contribution to the reflectance has to be corrected to get the surface water properties
- Medium-spectral bands data may contain effect of multiple WQ parameters
- In the coastal zones data may contain land contribution

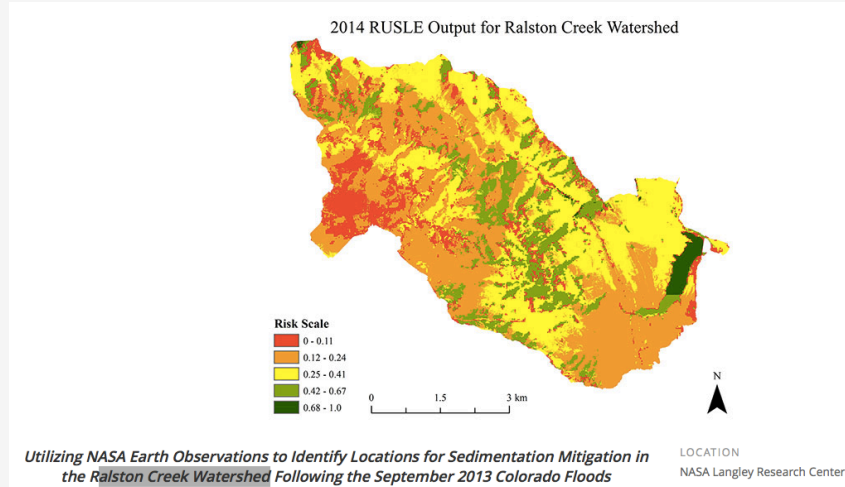
A satellite image of a coastal region, likely the Amazon River delta, showing a complex network of river channels and a large body of water. The land is green, and the water is a mix of light blue and dark blue. A semi-transparent white box is overlaid on the right side of the image, containing text.

Examples of NASA Remote Sensing Applications for WQ Monitoring

<http://arset.gsfc.nasa.gov>

Sedimentation Mitigation in a Colorado Watershed

NASA DEVELOP Project - <http://develop.larc.nasa.gov/>



End User: Denver Water

- This project helped determine excessive runoff and sedimentation due to extreme rain and flooding in Denver area, and provided a fine scale map detailing potential erosion mitigation sites

Learn more:

[http://develop.larc.nasa.gov/2015/
summer_term/
ColoradoWaterResourcesII.html](http://develop.larc.nasa.gov/2015/summer_term/ColoradoWaterResourcesII.html)

Wastewater Plumes Monitoring

NASA Develop Project – <http://develop.larc.nasa.gov>

Cooler sea surface temperatures (SSTs) were observed from satellite in the vicinity of the shorter outfall pipes during the 2006 HTP and 2012 OCSD diversions (Figure 2). The observed SST response is most likely due to the entrainment of cold subsurface water as the buoyant wastewater released at depth rises to the surface.

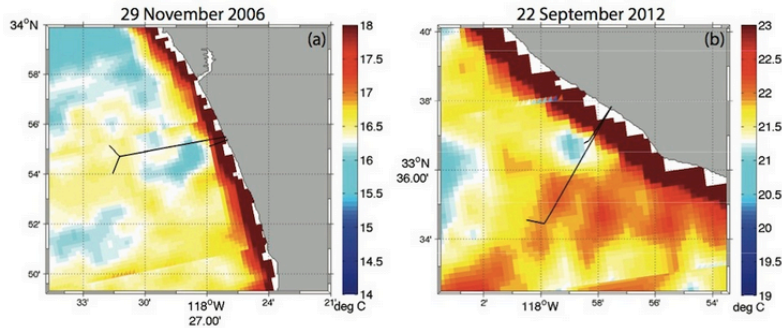


Figure 2. MODIS-Aqua SST ($^{\circ}\text{C}$) during the (a) 2006 HTP diversion on 29 November 2006 and (b) 2012 OCSD diversion on 22 September 2012. The long and short outfall pipes are shown. Low SSTs are indicative of the plume signature and are observed in the vicinity of the short outfall pipes.

Sea Surface Temperature near the Outflow pipes in the Southern California Bay

End Users:

Hyperion Treatment Plant (HTP) and Orange County Sanitation District (OCSD), Southern California

- Remote Sensing Measurements were used to detect wastewater plume and impact in the southern California Bight

Learn more:

http://podaac-www.jpl.nasa.gov/OceanEvents/2014_10_22_WastewaterDiversions

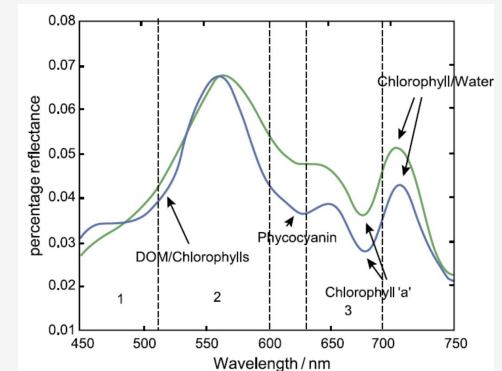
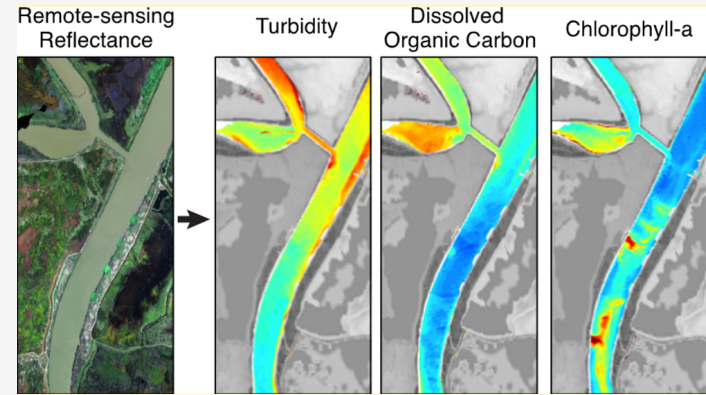
Airborne Remote Sensing for Water Quality Monitoring

1. Water quality monitoring at high spatial resolution (2 m) in California Bay-Delta

<http://pubs.acs.org/doi/abs/10.1021/acs.est.5b03518>

2. Monitoring of harmful algal bloom in Lake Erie (Summer of 2004)

<http://www.epa.gov/sites/production/files/2014-12/documents/habs-davis-12-10-14.pdf>



Water Quality Monitoring using MODIS and VIIRS

In the Gulf of Mexico

USF UNIVERSITY OF SOUTH FLORIDA

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College of Marine Science

Optical Oceanography Laboratory

Central West Florida Region & Data Description ? Tips Animate

Nov 2015

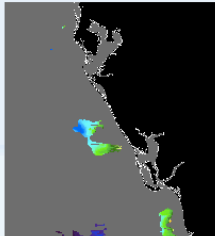
Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Menu

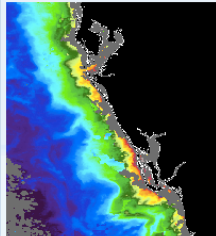
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MODIST 03:50 GMT MODISA 06:30 GMT MODISA 08:10 GMT VIIRS 17:52 GMT VIIRS 19:33 GMT

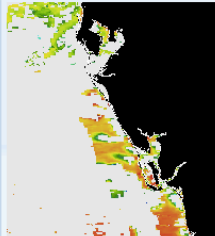
Composite DOY 326



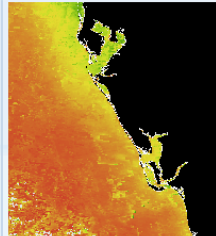
CHL 3DAY Information
Get Link Here GE



CHL 7DAY Information
Get Link Here GE



SST 3DAY Information
Get Link Here GE



SST 7DAY Information
Get Link Here GE

Learn more: http://optics.marine.usf.edu/cgi-bin/optics_data?roi=CWFL¤t=1

Research to Application and Decision Support

NASA Applied Sciences Water Resources Program supports applied research for water quality monitoring and decision support activities, for example:

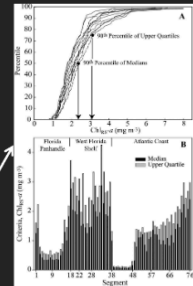
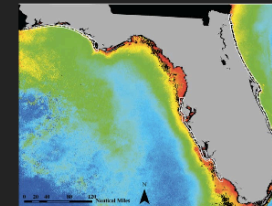
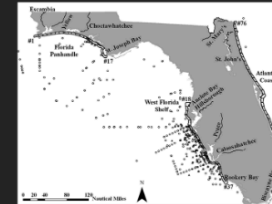
“Testing the Waters: Remote Sensing Applications to Water quality Management in Florida” -- Lehrter et al.

https://c3.nasa.gov/water/static/media/other/Lehrter_-_Water_Quality_Management_in_Florida.pdf

Nutrient Criteria Development

Based on our work, Florida implemented nutrient criteria derived using satellite data products

- Nutrient criteria were developed for all of Florida's coastal waters using the satellite data records
- The methods were vetted by the EPA Science Advisory Board and could be used by other coastal states and states with large inland waters where remote sensing can be used reliably.



(Schaeffer et al. 2012; 2013)

Thank You

The course material is available from

<http://arset.gsfc.nasa.gov/>

ARSET Listserv:

<https://lists.nasa.gov/mailman/listinfo/arset>